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LA RECHERCHE AGRONOMIQUE POUR LE DÉVELOPPEMENT

EU-PEARLS FP7

ALTERNATIVES SOURCES OF NATURAL RUBBER GUAYULE & KZ DANDELION

S. PALU (CIRAD/ FRANCE)

IN COLLABORATION WITH RESEARCHERS OF THE EU-PEARLS PROJECT

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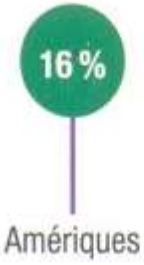
Hevea plantation, Guatemala
Tropical climate

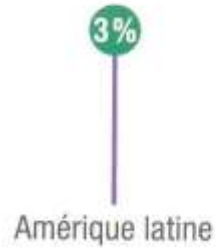
Guayule field, Spain
Semi-arid/mediterranean climate

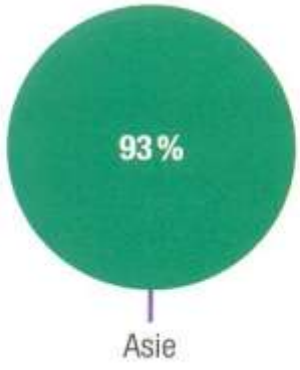
TKS field, Germany
Temperate/cold climate

WHY ALTERNATIVES SOURCES OF NR ?

- *Hevea,* only commercial source of NR (93% in Asia)
- Growing NR demand of emerging countries (China, India)
  5 M.T.(1990) up to 16 M.T. (2025)
- Price NR & SR linked with volatile oil price (90-180 US $)
- Replacement of rubber plantations by palm oil plantations







NR Consumption (*source SNCP & IRSG)*

NR Production (*source SNCP & IRSG)*

WHY ALTERNATIVES SOURCES OF NR ?

- NR prices have rocketed upward (4,80€/kg, Feb. 2011)
- Threat M*icrocyclus ulei* (SALB) (South America), but the risk to spray in Asia/Africa exists. When ? How ? Effect of climatic changes & global warming ?
- Hevea latex immediate proteins allergy and IgE anti-bodies induce hevea latex allergy. No allergy with guayule latex.
- Hevea labor intensive, cost will increase, social aspect (NGO)

  Guayule and TKS harvest is mechanized

HOW TO GUARANTY NR SUPPLY

- **New plantations & replanting**
  8.3 M. ha in production, 11,4 M. ha with young planting.

- **Improve SALB Hevea clonal resistance**

- **Study and develop new alternatives**
  - **GUAYULE**
  - **Kz DANDELION,**
  - **BIO-ISOPRENE™ (Genencor-Goodyear 2013 ?)**

- **European/International guayule & TKS projects**
  EU-PEARLS(2008-2012), G-VALUE (2013 ?)
  (Web site : http://www.eu-pearls.eu/UK)

WHAT IS GUAYULE ?
(Parthenium argentatum Gray)

- Bush (50-100 cm high), native from Mexico. Plants from 2 to 10-12 years*, 40 Y.* in the wild

- Perennial, native C. 250-450 mm rainfall, T°-23°C/ +49°C. Commercial C.: soils well-drained,T°C.$_{min}$-9°C,380-640 mm. First harvest after 2 years then every year for 10-12 Y.
- Irrigation. Nursery plants. Density: 55,000 plants/ha.

More biomass ≈ more rubber

- USDA cultivars: AZ2,AZ1,AZ3,CAL 6,11591,N565,593

- Rubber content : 5–12% dry weight branches, less roots and leaves (low Mw).

Yield : 500- 1.000 kg / ha/ an.

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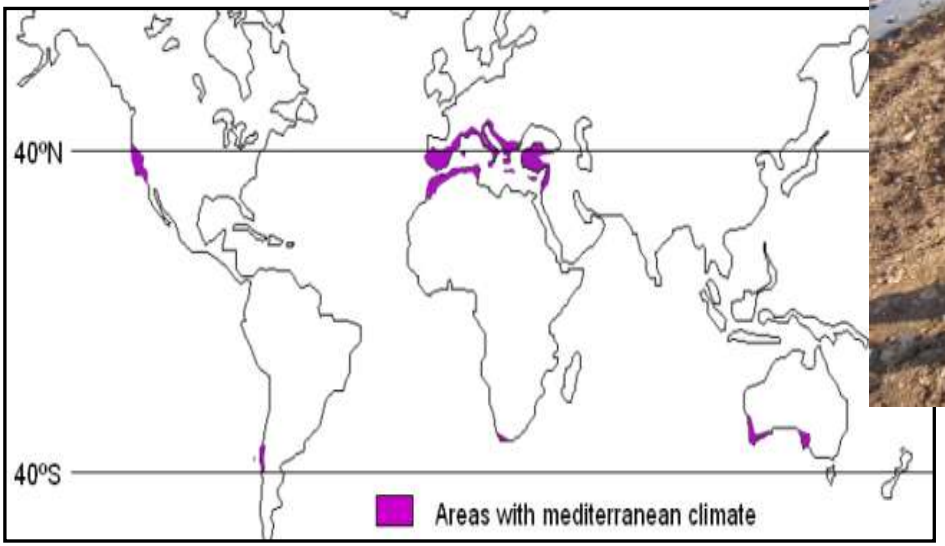
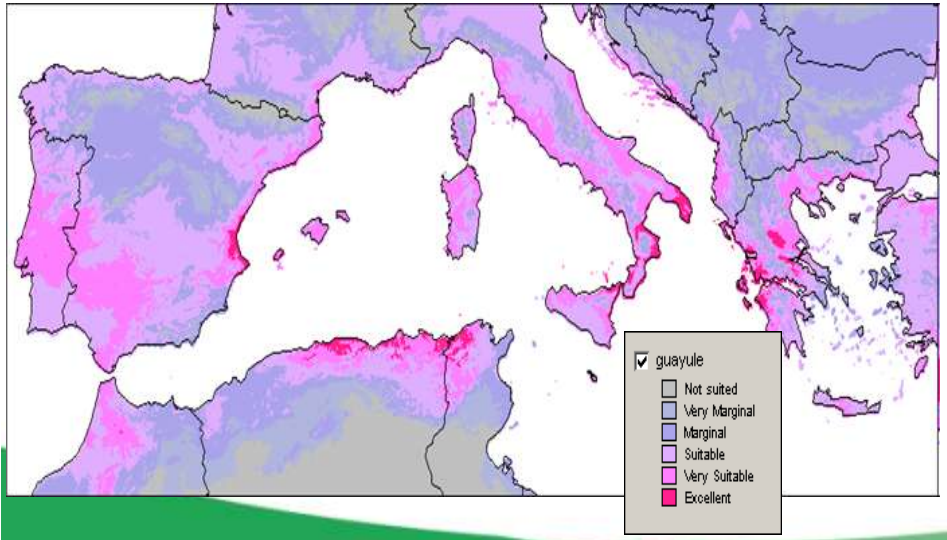
WHERE DOES GUAYULE GROW?





GUAYULE DEVELOPMENT HISTORY

- **1906- 1912 :** 55.000 T. of GR (1.000 T. less than Hevea)
- **WWII**: Emergency Rubber Project, 8,000 ha, failure when access to Asian plantations & SR development.
- **1950**: GR attempt in Europe (Spain, Italy)

- **1970s**: Oil embargo. R&D in California, Arizona, Australia,
- **1980s**: Plant in Saltillo (Mexico). Firestone plant in Sacaton -AZ.
- CIRAD projects Morocco & West Africa
- **2000**: YULEX/USDA, hypoallergenic latex (K. Cornish)

GUAYULE DEVELOPMENT HISTORY

- **2008**:EU-PEARLS, fields in France (Montpellier),Spain (El Molinar/Murcia).Prototypes gloves + tyres

- **2012**: Bridgestone Project on sustainable source of NR, Yulex new factory in Chandler, AZ.
  Cooper Tire/Yulex to develop GR polymers + resins for tire

- **2013**: Bridgestone interest for uses bioproducts
  Yulex joint venture with Versalis & Pirelli in Italy.
  Panaridus/USA project in India ?
  New EU project in 2013 ? (Spain, France, Italy, Greece, Morocco, Kazakhstan)

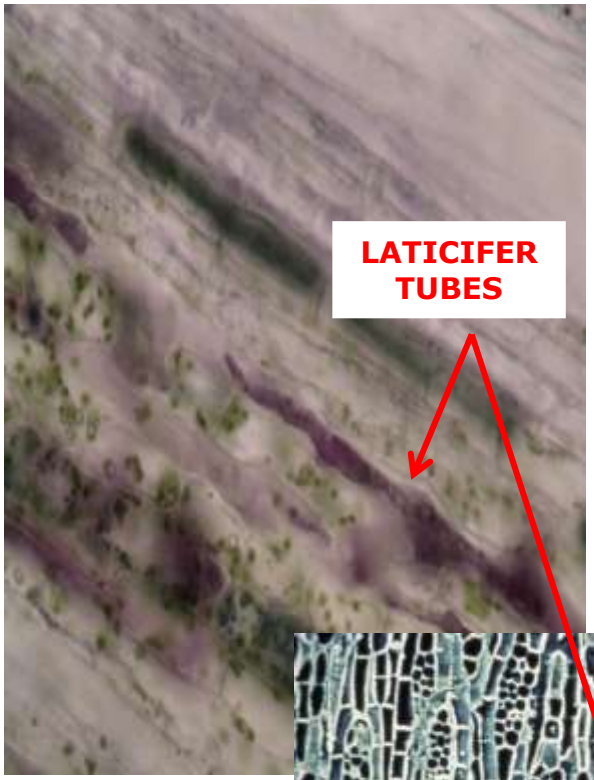
RUSSIAN & KHAZAKSTAN DANDELION (*Taraxacum kok saghyz)*

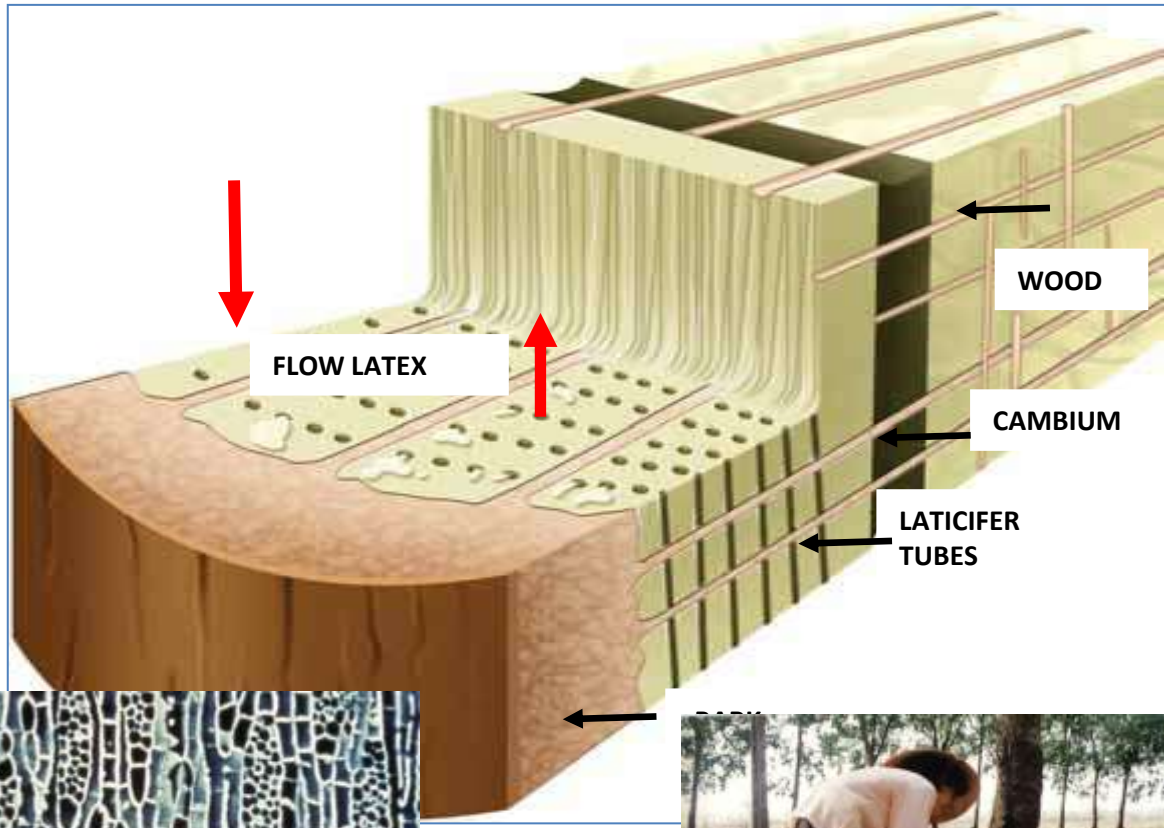
- **TKS native from Kazakhstan. Annual. T°C (–30°/40°C). Family: *Asteraceae.* Rubber (3-24%). Inulin (36%).**
- **Latex flows but coagulate quickly.**
- **German researchers (Aix-la-Chapelle,U. Münster), GMO TKS, 4-5 more rubber content than wild TKS.**
- **Research on genetic, PENRA & EU-PEARLS project in Netherlands, Germany, Spain, Czeck Republic**

KZ DANDELION DEVELOPMENT HISTORY

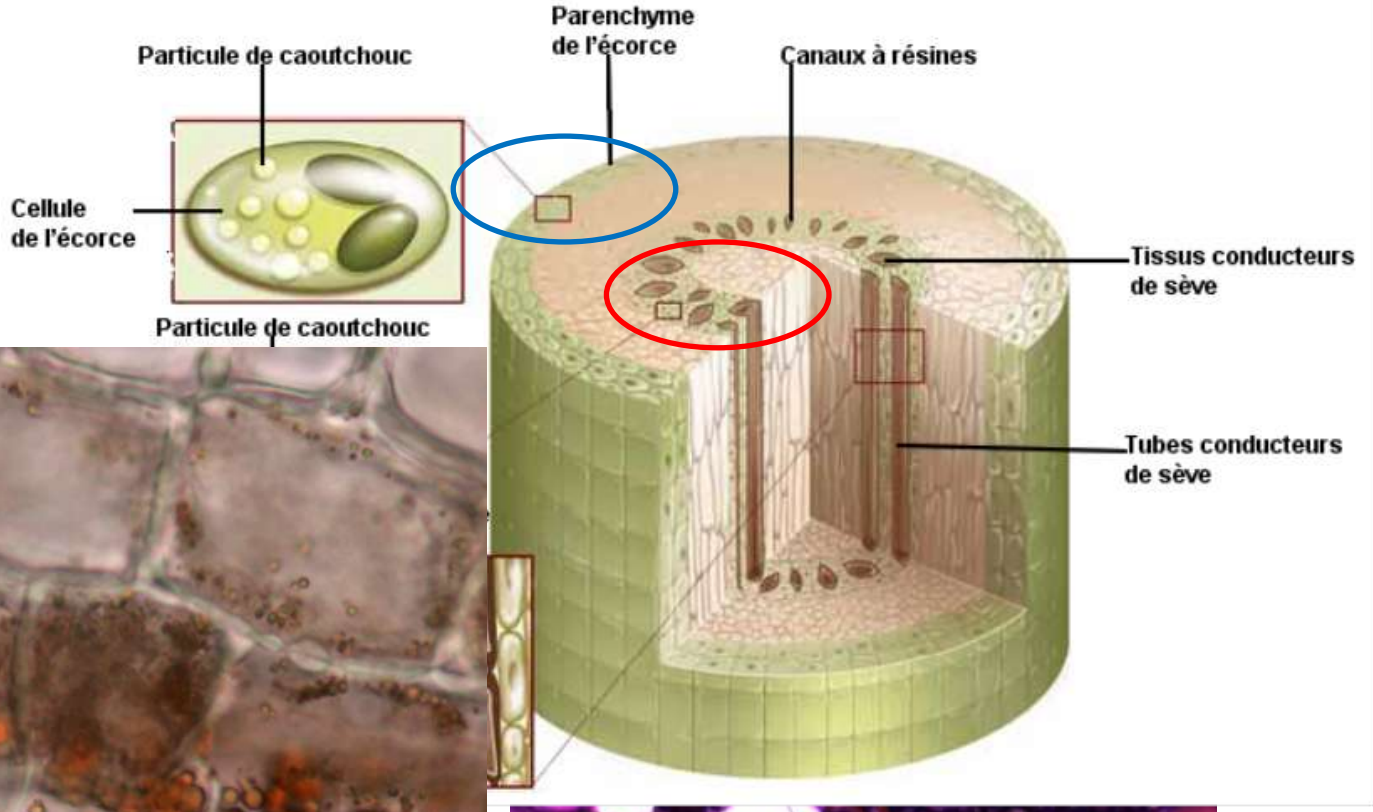
- **WWII**: 100.000 ha in the ex-URSS and Germany
- **2008**: Ohio (USA), PENRA project. EU-PEARLS project
- **2012**: NovaBioRubber Green Technologies (Canada). Patent on TKS rubber.
- **2013**: Bridgestone Corp. & Ohio State University, claim TKS commercially viable, renewable source of tire-grade rubber.
- **2015**: Novabiorubber & Universities Canada will develop an industrial plant for TKS rubber

HEVEA LATEX CELLS STRUCTURE

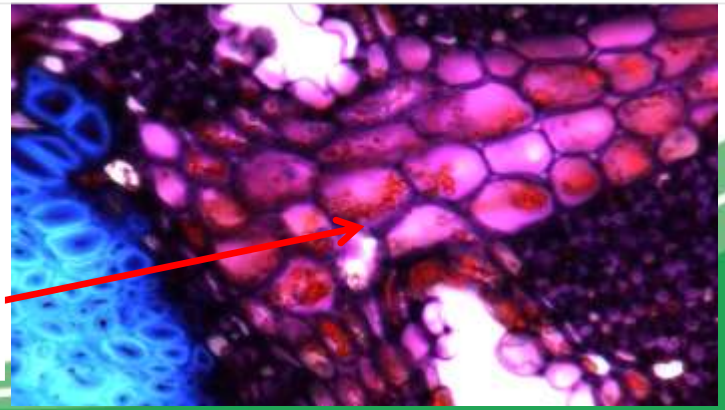




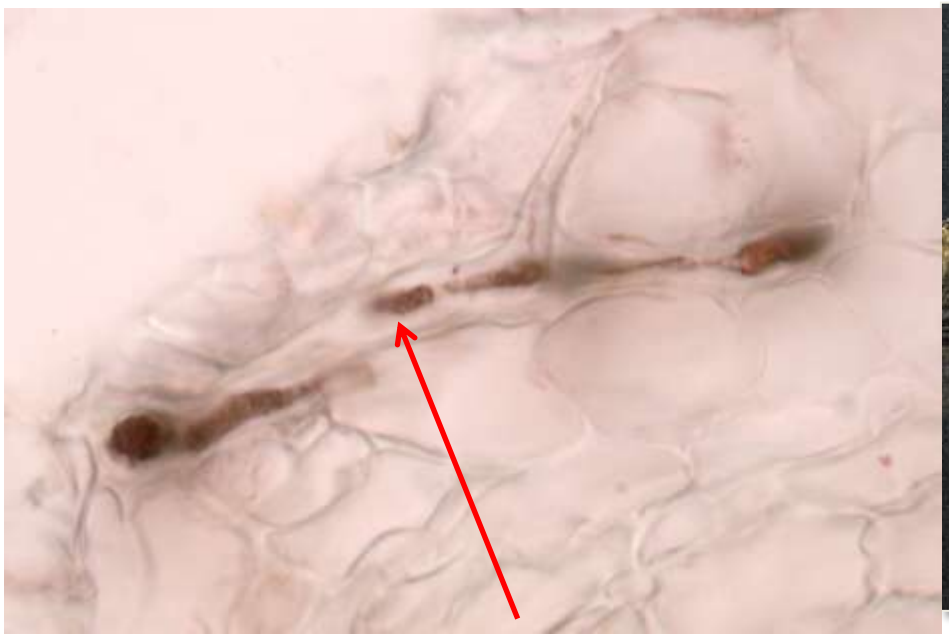
GUAYULE LATEX CELLS STRUCTURE



RUBBER PARTICLES IN CLOSED CELLS



DANDELION LATEX CELLS STRUCTURE



Laticifer tube in Dandelion root
Secondary phloem

Source D. PRUEFER, U. Munster GR

Latex vessels similar to *Hevea*,
but no connection between latex vessels.

GUAYULE RUBBER EXTRACTION PROCESS

HARVEST

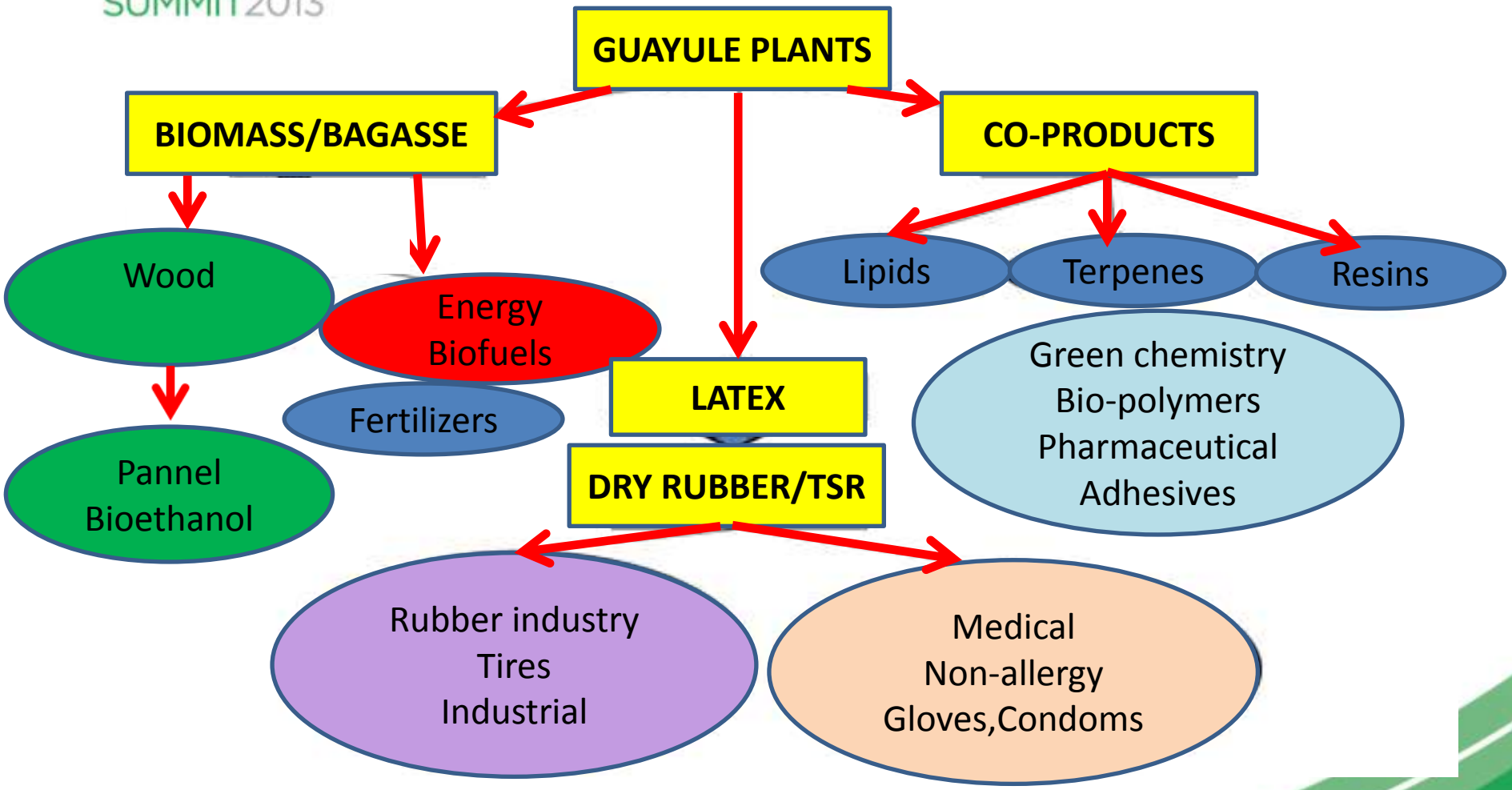
WATER LATEX PRODUCTION	SOLVENT DRY RUBBER & RESINS	CO2 SC Fluid Resins & Low Mw
YULEX USDA CIRAD	SALTILLO/CIQA TEXAS A&M FIRESTONE/SACATON (1980s) PANARIDUS (2012)	USDA/YULEX

YULEX COMMERCIAL (500-1000 T./Y)

Over 35 patents

RESEARCH

GUAYULE BIO-REFINERY



DANDELION RUBBER EXTRACTION PROCESS

HARVEST

WET PROCESS LATEX

Soviet Tech (1936).
ESKEW (1940)
PENRA process (2012)
Primary, Secondary
Milling Screening,
Centrifuging Flotation

Source
OHIO
State U.
OARDC

PILOT

DRY PROCESS RUBBER

NovaBioRubber
25°C, mechanical, green additive (US Patent #7,540,438)
200 T./Y.

Source
Nova
Biorubber

PILOT

MICROSTRUCTURE CHARACTERISATION

- NMR_{C13}, FTIR, DSC ⇒ GR, TKSR and HR , all PI cis 1,4
- SEC-MALS analysis: molar mass (Mw) varies with age of plants, storage conditions, extraction process, method of measurement, aging.

Type	M_w (kg/mol)	Gel rate%
Hevea-TSR20	1200- 1490	48
Synthetic PI SKI 3	1451	13
Guayule GR	450 - 2200	15
Guayule (Saltillo)	792	-
R.Dandelion TKSR	472-1980	34

GUAYULE LATEX PROPERTIES

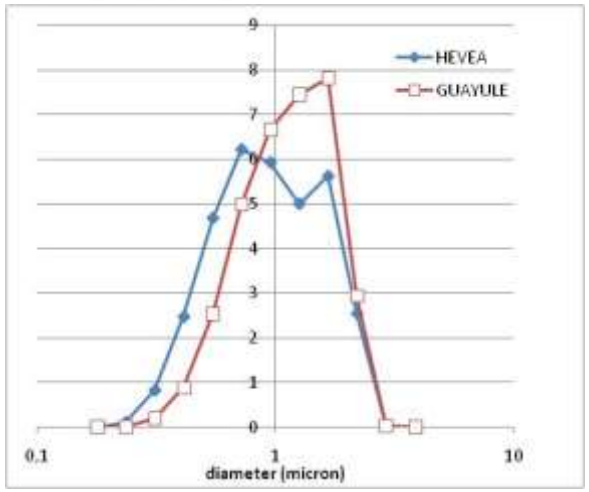


Photo CIRAD/CTTM

	HEVEA LATEX	COMMERCIAL GUAYULE LATEX*
Solid content (%)	**61.4**	**55.6**
Viscosity (Cp)	**48**	**53**
pH	**9.6**	**10.9**
Average size (µm)	**1.0**	**1.2**

Commercial YULEX

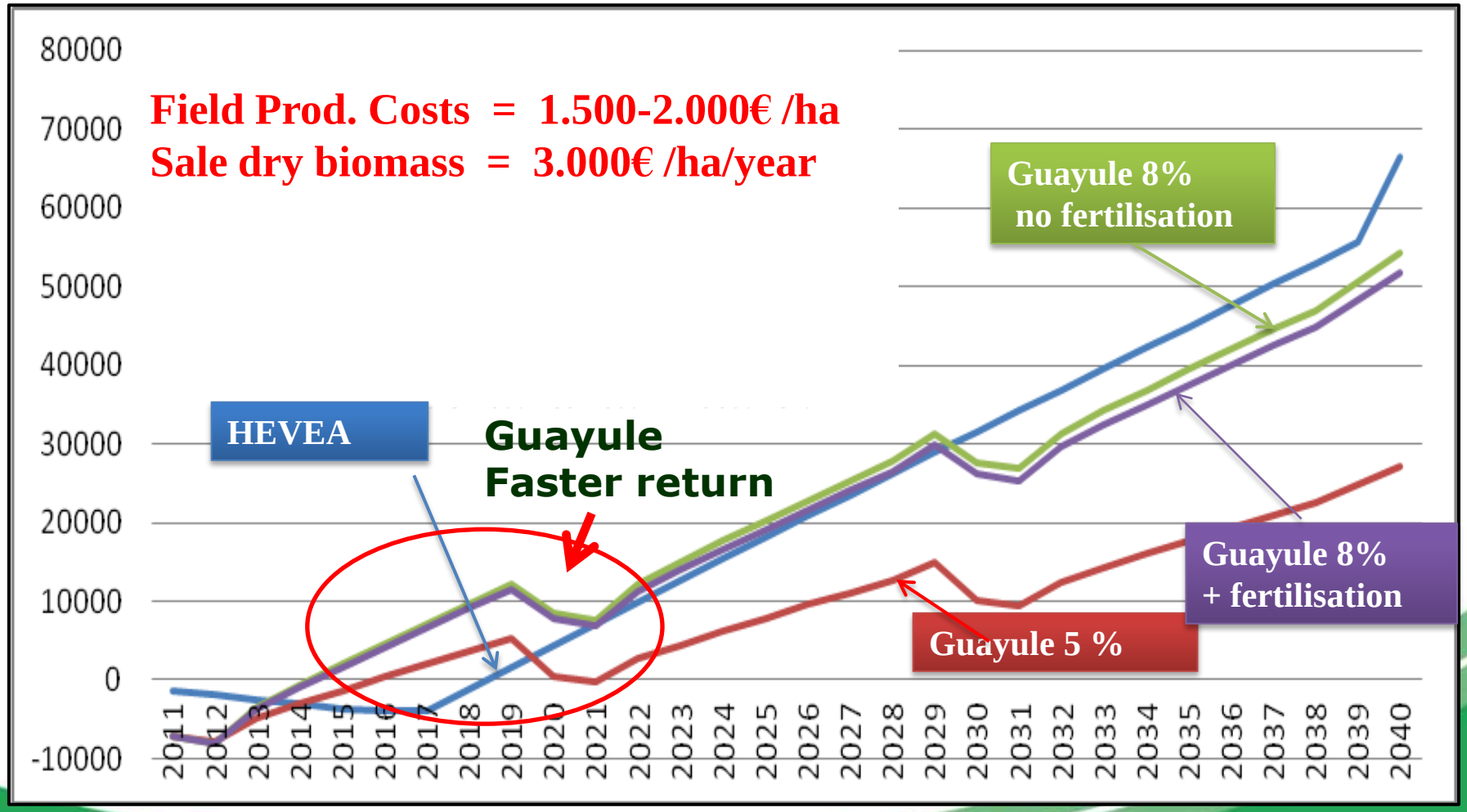
GUAYULE and HEVEA gloves mechanical properties similar with formulation adaptations

TSR RUBBER PROPERTIES

PROPERTIES	GR	HR
Initial Plasticity P0 , ISO 2007	31-33	>30
Plasticity retention indice PRI (ISO 2930)	**6.5-15.2**	**>40**
Mooney Viscosity ML (1+4) 100° C ISO 289-1	52 -53	60-80
Dirt content % ISO 249	0.016 0.038	<0.20
Acetone extract ISO 1407	12 -14	<0.5
Ash content % ISO 247	0,19-1.25	<1.00
Total nitrogen ISO 13878	0.21	<.60

Accumulated balances of hevea and guayule cultivation

Source : Nisrin SFEI IAMM/CIRAD 2011-2012 with « Olympe » software (for publication)



THRESHOLD SELLING PRICE OF GUAYULE RUBBER

Source **: CIRAD not yet published**

Option 1: only Latex (centrifugation)

- With current technology, it is possible to extract 60% of the total rubber as latex.
  - The valorisation of sole guayule latex would be possible only through a niche market with very high added value.

Option 2: only crude rubber + resin (solvent extraction)

- With current technology, it is possible to extract 90 % of rubber + 95 % of the resin.
  - ✓ (*Prices recorded in 2011*).

Option 3: Latex as step 1, followed by **crude rubber + resin** as step 2.

- It is possible to extract 25 % of latex + 65 % of crude rubber + 95 % of resin.

Threshold selling price (€ /kg) to reach profitability

Option	Latex	Crude rubber	Resin
1. Latex only	8.0-9.0		
2. Solvent only		4,0	3,0
3. Latex, then solvent	5.0	3.0	3.0

CONCLUSION

- **Guayule (GR) & KZ dandelion (TKSR) not a threat to Hevea**

  If Hevea NR capacity not available, alternative raw materials will develop.

  ***Brazil, major NR producer until 1920, before Asian rubber plantations)*. Markets change.**

- **Commercial production for GR and TKS (5,000 T. in 2025)**
  - **Price of NR (> 3.0 $US /kg),**
  - **High rubber Yield /ha (≈1 ton/ha target),**
  - **Lower costs of production, efficiency of processing**
  - **New cultivars, genetic improvement,**
  - **Valorisation of bioproducts and bio-refining**

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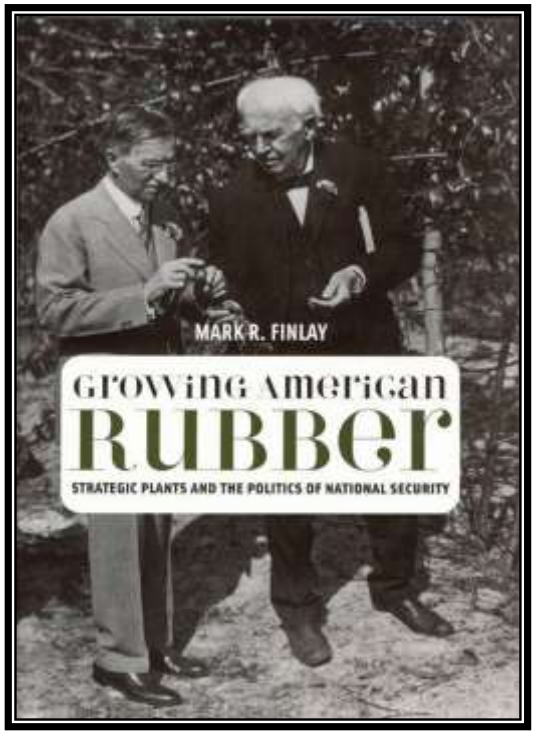
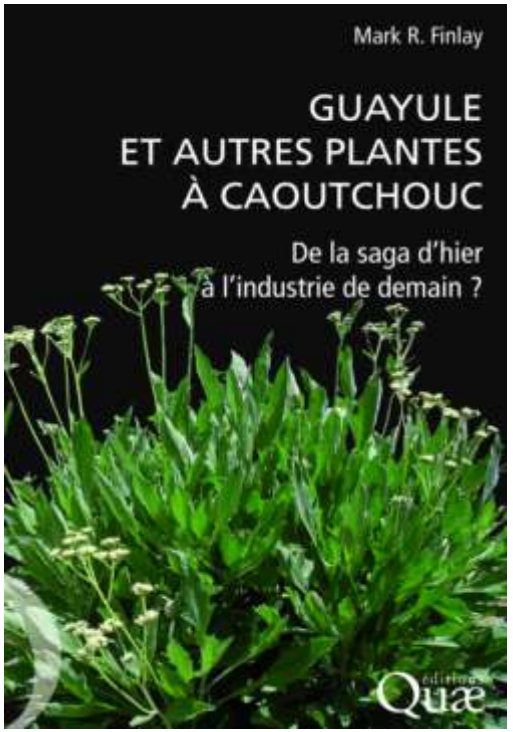
- Car sales (China, India) important parameter.
- More commercial plants of GR and TKSR needed with higher capacity, new areas for planting
- Tyres and industrial rubber companies, national and international organizations more involve on alternatives sources of NR.
- New cultivars with higher yield (> 1T./Ha/Y)
- More economics & feasibility studies





Growing American Rubber: Strategic Plants and the Politics of National Security **(Rutgers University Press, 2009) by Mark R. Finlay**
Translated into French by D.Michelin

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THANK YOU

"Catch the Alternative Natural Rubber ball"